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Meloidogyne exigua, a root-knot nematode of coffee

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HISTORICAL

More than 100 years ago, in 1877, Jobert conducted field observations on the diseases of coffee trees in the Province of Rio de Janeiro, Brazil. In his report he noted that galls and "nematoid" worms were observed on the roots of some diseased trees, but apparently he was unable to conduct further studies in relation to the problem (12).

Due to the persistent spread of the coffee decline disease in Brazil during the 10 years that followed, Dr. Emilio A. Goeldi conducted an extensive study on coffee diseases and was first to indicate the primary role of root-knot nematode in coffee decline. In his report to the Brazilian government in 1887, he described the coffee root-knot nematode, *Meloidogyne exigua* Goeldi, and established the genus *Meloidogyne* (11). Lordello and Zamith published a more detailed description of *M. exigua* in 1958 (17).

Fig. 1. Stunting of coffee plants caused by *Meloidogyne exigua*. Inoculated plant, left; noninoculated plant, right.

Through his careful observations and experimental work on coffee decline, Goeldi established himself as a pioneer in yet another area of plant pathology and nematology. More than one-half a century before most plant pathologists and nematologists approached disease problems by considering complex interactions of fungi and nematodes, Goeldi described an etiological complex involving *M. exigua* and fungal organism(s) on coffee seedlings and coffee trees. Although Goeldi in this first description of a disease complex did not establish the taxonomic position of the fungal organism(s) involved, drawings from his histological studies strongly suggest that *Rhizoctonia* sp. or/and *Roselinia* sp. were involved in this disease complex (8,11). Following is a translation of a summary that Goeldi wrote based on his observations from histological and pathogenicity studies: "...we may have the following conclusions: this coffee disease is essentially a root disease; and their pathological alterations are: (1) presence of numerous nodosities inhabited by a worm of the order of nematodes; (2) presence of a microscopic fungus. Between these two agents, the primary importance must be the nodosities, the fungus being only the field helper..." (8,11).

HOSTS AND DISTRIBUTION

Compared to many other species of root-knot nematodes, *M. exigua* has a restricted host range. The most common host of this nematode is coffee, *Coffea arabica* L. It has been reported on this host in Brazil, Colombia, Peru, Venezuela, Costa Rica, Guatemala, El Salvador, Dominican Republic, Martinique, and Trinidad (5,15). Chitwood also recovered it from the roots of a coffee

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plant in the New York Botanical Gardens (5). Other plants that are known to be hosts of *M. exigua* in Brazil are *Allium cepa* L., *Capsicum annuum* L., *Citrullus lanatus* (Thunb.) Matusum. and Nakai, and *Solanum nigrum* L. (14,15,22). *M. exigua* has also been reported to infect citrus in Guadeloupe and Surinam and *Camellia sinensis* L. in Peru (9,16,26). In Florida, it has been recovered from prayer plant, *Maranta leuconeura* E. Morr. (unpublished Div. of Plant Industry record). In Bolivia it occurs on 'Dwarf Cavendish' banana, *Musa acuminata* Colla. In South India, *M. exigua* is reported on two species of weeds, *Bidens pilosa* L. and *Pilea* sp., growing in coffee plantations, but was not found on coffee roots in the same area (5,15).

SYMPTOMS AND HOST-PARASITE RELATIONS

Above ground symptoms frequently associated with *M. exigua* are chlorosis and premature defoliation (15). Infected plants may be severely stunted (Fig. 1). In one experiment, the height of inoculated plants was reduced 30%, and yield was reduced more than 50% compared to non-inoculated plants (2,3).

The root system of coffee plants infected with *M. exigua* is conspicuously reduced, especially secondary roots and root hairs. *Meloidogyne exigua* usually produces small galls, most frequently on the terminal portions of the roots (27). In some instances, *M. exigua* does not form galls on coffee roots, but mature females usually break through the root surface and may be seen as globular whitish bodies with yellowish or brownish egg masses attached (15). The cracks form when the females break through the surface and serve as portals of entry for numerous secondary organisms; under these conditions the nematode may contribute more injury to the host than in those cases where smooth, uncracked galls are formed (15).

M. exigua is capable of inducing physiological and morphological changes commonly associated with many root-knot nematodes that cause root galls. Histological studies of the roots of coffee with females of *M. exigua* indicate giant cells are formed through dissolution of cell walls, coalescence of contents of several cells, and successive mitoses without cytokinesis. Large cytoplasmic vacuoles with distinct membranes are frequent in the giant cells. Usually, the giant cells are found in the interior of the central cylinder, often occupying its whole diameter and causing the collapse of the vascular system (19). The alterations in root physiology and morphology may affect nutrient uptake. Coffee plants infected with *M. exigua* have reduced zinc and boron uptake and are also more susceptible to cold injury and drought (15,18).

INTERACTIONS WITH OTHER ORGANISMS

Research by DeSouza in 1977 confirms that Goeldi in 1887 correctly concluded, based on his microscopic and histological observations, that fungi may interact with *M. exigua* and augment damage caused by this nematode. DeSouza's experiments indicate that although *Rhizoctonia solani* Kuehn is capable of causing damping-off and root rot of coffee seedlings 3 months old or less, this fungus alone normally has little effect on older coffee plants. Coffee plants inoculated only with *M. exigua* had a relatively low average percentage (5%) of root necrosis. Plants inoculated with *M. exigua* and *R. solani* simultaneously had only a slightly higher percentage of root necrosis. When *M. exigua* inoculation preceded inoculation with *R. solani* by 20 or 50 days, the average percentage of root necrosis increased to 18 and 21%, respectively. The interaction of these two organisms in causing disease on coffee was affected by temperature, cultivar, and age of host plant. In all cases, however, *M. exigua* preceding *R. solani* in roots of coffee seedlings caused more root necrosis and defoliation than when both pathogens were inoculated either simultaneously or separately (8).

CONTROL

The spręad of *M. exigua* into new areas can be best prevented through nursery sanitation practices that lead to the production of coffee seedlings free of nematodes. A number of nematicides have been found to be effective in controlling this nematode (4,7,13,16,24). Chemical control in the field has limitations, especially if seedlings are severely infected with *M. exigua*. If a high number of larvae infect the tap root near the crown, the vascular system may be damaged to the extent that plants show poor growth, even after nematodes are controlled chemically. For this reason, nematicides are often used as a preventive measure in nurseries. By law, in Brazil, soil in which coffee seedlings are grown must be treated with a broad spectrum fumigant such as methyl bromide.

For older trees, depending on the stage of decline and nematode population levels, treatment with nematicides is often only marginally cost effective, especially if repeated applications are necessary (15). Crop rotation or fallow is recommended prior to replanting in areas infested with *M. exigua* (23).

M. exigua apparently has a limited survival in soil in the absence of a host. Moraes and Alvarenga, working independently, found that *M. exigua* populations disappear in the soil 6 months after elimination of the old coffee trees (1,20). Lordello states that replanting the area with nematode-free young plants, probably within 12 months, would be a practical approach to the rehabilitation of an infested area (16).

This nematode can also be controlled through resistant cultivars or rootstocks, and in recent years there has been considerable progress in developing extensive breeding programs for this purpose in the coffee-growing regions of Brazil and other countries where *M. exigua* is a problem (6,10,21). There is also evidence that races of *M. exigua* occur in Brazil and Guatemala, and this will be an important consideration in developing effective breeding programs for controlling this nematode (5,25).

SURVEY AND DETECTION

Most plants infected with *Meloidogyne* species exhibit root swelling or galls. Galled roots from known hosts of *M. exigua* should be submitted for identification of the species of root-knot nematode present.

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